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Innovation Process in Medical Imaging

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Abstract

This article reviews improving process in medical imaging thanks to innovation and technology. Medical imaging is the technique and process used to create images of human body for clinical purposes or medical science. Since Wilhelm Roentgen's discovery of X-rays in 1895, medical imaging has undergone near continuous innovation. After the Second World War, multiple generations of innovations and new discoveries, focused on the interaction of computerization and imaging technologies, took place in X-ray, computed tomography, magnetic resonance imaging, nuclear imaging, and ultrasound-positioned medical imaging, led to transforming healthcare science**.** Medical imaging has brought a high sense of vision into medical science, leading to an extensive change in healthcare system.

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Keywords: Medical Imaging, Innovation Process, Improvement, Progress;

1. Introduction

Although the term is broadly used, innovation generally refers to the creation of better or more effective products, processes, technologies, or ideas that are accepted by trades, society and governments (Wikipedia, innovation, 2012 Nov. 12, last modified).

Medical imaging refers to the technique and processes implemented to make images of the parts or function of human body for clinical purposes including to diagnose diseases or medical science such as the study of normal anatomy and physiology thereof (Wikipedia, Medical imaging, 2012 Nov. 16, last modified).

Medical imaging has transformed the healthcare science. Innovations in medical imaging have created faster and more precise imaging that are less invasive. This caused to wide use of imaging for more conditions and for more patients. Former, imaging was thought as a diagnostic tool for diseases, but now it is also used to treat, manage, and predict illnesses. It has become a need for almost all major medical conditions and diseases. Medical imaging is one of the standards of new medical care for diseases such as: cancer, cardiovascular disease, trauma, and neurological conditions, and many others. It has been used by a wide range of medical specialists, from oncologists to internists (NEMA, 2006 Dec.).

Innovations in medical imaging cover the entire health care science, from the medical research to the medical practice, which means for the individual patients and the medical care efficiencies (Davis, J., 2010).

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Today, medicine is capable to make effective treatments for diseases and injuries through establishing on the discoveries and knowledge which exist. This steady increase in medical transformations and innovations in healthcare science is a useful means to meet the urgent needs of patients diagnosed, particularly in life-threatening conditions, which attempts to transform our understanding of disease. In many cases, innovation requires that we put aside what our thoughts and start fresh (ASU, 2010).

These medical transformations and innovations, have led to:

- Enabling physicians to see inside the body with clarity and to infer or guess how diseased an organ is or how blocked an artery might be. One of the important transformations and main achievements in modern medicine is to enable our physicians to make treatments with less-invasive methods.
- Less invasive and precise medical therapies, which are provided by medical imaging led to better treatments and more comfortable care for the patients. Since these treatments are less invasive they cause fewer complications, shorter hospital stays, and in many cases, no incisions or surgery (Davis, J., 2006). This change and revolution in medical care is largely made by technical advances in modalities that resulted from fruitful interactions among the basic science, medical science, and manufacturers.

Today, we need to the medical imaging enabling us to see inside the human body and to interfere noninvasively. Modern medicine provides accurate, fast and less invasive diagnosis and therapies with the help of medical imaging. This article gives a concise and clear outline of the improvement process in medical imaging, with a simple description; guides to realize how innovations and improvements in medical imaging enabled physicians to more accurate diagnose and treat illnesses with less invasive methods.

2. Material and Method

This article reviews an outline of innovation process in medical imaging. Key issues were identified through review of literature on innovation process in medicine and through review of literature on the medical imaging. It starts with a brief history of medical imaging, continues with brief description of improvements thereof, and concludes how innovations in medical imaging help physicians to make better diagnosis, manage and treat patients with less harm.

3. Results

During the 19th century, machines were more implemented for diagnosis or therapeutics in medicine (Raiser, S.J., 1978). The use of electricity resulted in the invention of the x-ray. Electromagnetic radiation in a wavelength range commonly known as X-rays was first discovered by a German professor of physics, Wilhelm Roentgen. Because of the unknown nature of his discovery, he called them X-rays. They are also still known as Roentgen-rays, particularly in Germen-speaking countries. Before the Roentgen's discovery, many people had observed the effects of X-ray beams, but he was the first one to study them systematically. He discovered a radiation that could penetrate solid objects of low density, could be viewed on a fluorescent screen and stored on photographic film. Physicians gained the ability to view the inside of the body, by using X-rays (Marks, H.M., 1993; Miranda, M. A. De, Doggett, A. M., Evans, J. T., 2005; Castillo, J.J., 2010).

Stemming from Roentgen's discovery in 1895, medical imaging has undergone remarkable improvements. It was after the Second World War that the interaction of computerization and imaging technologies took place. Before that time, the main focus was on the processing of X-ray technology. After the War, multiple generations of innovations and new discoveries; some amazing, some augmenting, in X-ray, computed tomography (CT), magnetic resonance imaging (MRI), nuclear imaging, and ultrasound (US), made medical imaging to have a renewal role in modern medicine (NEMA, 2006 Dec.)

Using medical imaging increased rapidly. Imaging has become more accurate, smaller, faster and less invasive due to the progresses in electronics, miniaturization, visualization, and computing power, as well as advances in imaging acquisition, resolution, transmission, and manipulation (Margulis, A. R. & Sunshine, J. H., 2000).

Remarkable revolutions in the medical imaging industry are taking place; making a move from expensive, large, stationary, and complex systems to smaller, easier to use, and more accessible devices. Technological advances in medical imaging led to use the devices in small hospitals, physicians' offices, and on wheels outside medical settings, not just be limited to the large hospitals and institutions. Newer imaging technologies focus on combining ease-of-use with higher levels of accuracy, allowing information to be accessed efficiently, while providing higher throughput. These new solutions are cost effective and can be used in a variety of clinical applications (Mitchell-Magaldi, D., 2008).

Transformations in design and materials of imaging led to more mobile and portable devices. Ultrasound created images by using only sound waves; MRI did so using magnetic fields. Progresses in imaging technologies also allowed physicians to watch in real-time as they snaked catheters through arteries to the heart, brain, or kidneys. CT scanning and mammography introduced new detail that enabled new diagnostic power and clinical capabilities. The development of digital imaging brought a new generation of efficiency and speed as it offered new options for data access and transmission—and vast new volumes of information (NEMA, 2006 Dec.).

Over the 20th century, medical imaging development was driven by technological innovation and engineering improvements in physical equipment. A new imaging modality driven by development of the biological knowledge base represents a fundamental change. Understanding such an important change is of utmost importance to medical physicists working in imaging research. The measure of success and the economic growth of medical imaging reside firmly in the ability to implement new procedures with higher diagnostic specificity and sensitivity (Fullerton, G.D., 2005; Hazle, J.D., 2005; Fullerton, G.D. & Hazle, J.D., 2008).

4. Discussion

Medical imaging often refers to label a set of techniques that make images of the inside of the body, noninvasively. Medical imaging can be viewed as the solution of mathematical inverse problems. It means that cause (the properties of living tissue) is inferred from effect (the observed signal). US probe produces ultrasonic pressure waves and echoes inside the tissue to show the internal structure. In the case of projection radiography, the probe is X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat. On the electromagnetic and radiation level, they are invasive; though the term noninvasive is used for these medical imaging modalities. These modalities affect the body in order to obtain data (Wikipedia; Medical imaging, 2012, Nov.16, last updated).Today, there is an enthusiasm to apply new medical imaging devices that can reduce the potential for errors, improve the quality of diagnosis and care. Better information of the medical imaging, enabling stakeholders interested in promoting or considering adoption, to identify what benefits to expect from working with these systems, how best to apply them to enhance advantages derived from their investment, or how to manage policy to increase the quality and efficiency delivered by the health care sector as a whole.

One of the most significant advances in radiology since the discovery of X-rays was the invention of the CT scanner in the 1970s. Radiologists brought in both cross-sectional imaging and digital imaging by using CT scan. As computing advanced, the spiral CT developed. Also, Multi-slice CT systems are now at the cutting edge in terms of speed, patient comfort, and resolution (Kalender, W.A., Seissler, W., Klotz, E., 1990).

Mansfield P. and Lauterbur P.C. gained the Nobel Prize in 2003 for their pioneering research on MRI. It is almost still a new technique, which is now used to investigate neurologic and musculoskeletal disorders, and patients with cancer. MRI creates good images with high resolution of rapidly moving structures as cardiovascular system. This capability is essential in imaging the heart, and it allows high-quality non-invasive peripheral arterial studies. MR contrast agents have progressed and blood pool agents are being developed for MR angiography, which is emerging as a viable non-invasive means of assessing vessels (Bydder, G. M. & Young, I. R., 1985). A magnetic field and radio wave pulses are needed to produce pictures in MRI test, instead of harmful x-rays. Information about body structures and some problems can only viewed via MRI test (WebMD, MRI, 2012 May 16, last modified). It is a way of seeing what’s inside the body, with no so much harm.

High-frequency sound waves are used in US to produce pictures of the inside of the body. Ionizing radiation is not used in US, as used in x-rays. Since US images are taken in real-time, they have the capability to show the structure and movement of the organs, such as; blood flowing through blood vessel (General Ultrasound Imaging, 2011 June 24). Since 1974, interventions such as biopsies and abscess drainage have been done through the US guidance. 3D fetal imaging (Baba, K., Satoh,K., Sakamoto,S., et al., 1989) and high-quality fetal US, have made intrauterine surgery of fetus, possible (Harrison, M.R., Adzick, N.S., Longaker, M.T., et al., 1990).

Work with digital subtraction angiography began in the late 1970s. Digital radiography and scanning laser-stimulated luminescence use digital signals instead of x-ray energy patterns, introduced a new technique. Using this technique makes it possible to visualize the major arteries after intravenous contrast injection (Ovitt, T.W., Christenson, P.C., Fisher, H.D. 3rd, 1980).

Mammogram is an X-ray test of the breasts used to screen women for breast problems and to detect breast cancer. Many small tumors can be seen on a mammogram before they can be palpable. First reports of digital mammography go back to Smathers, et al in 1986 and Asage, et al in 1987. In 1996 digital spot view acquisition systems become available for mammography (WebMD, Mammogram, 2011 Aug. 20; Asaga,T., Chiyasu, S., Mastuda, S.,1987).

Functional imaging emerged with the introduction of positron emission tomography (PET) scanning and, more recently, molecular imaging. PET scan evaluates functional and pathologic changes observed in tissues. Biomedical assays, including; visualization, characterization, and quantification of biologic processes taking place at the cellular and subcellular levels, are possible by molecular imaging. It is more applied to assess biologic processes in the cells of a living subject to detect their molecular abnormalities that form the basis of disease. This approach could alter cancer diagnosis and follow-up (Gambhir, S.S., 2007).

Change is needed in medicine as well as other sciences. We need to such physicians to be skilled technologically and driven toward innovation. As portable electronic devices in everyday life are more implemented and the explosion of social media increased, healthcare science needs to accept and adopt modernization in a way that we can start building guidelines for proper use of technology (Amanda, XI., 2011). Today, innovations in healthcare science is about to take off. Medical imaging is a large field, dealing with all areas of patient care, from diagnosis to intervention. Traditional x-ray film is being replaced by soft-copy images. Now we have US, CT, MR, interventional radiology and nuclear medicine including PET scanners, and safer agents have replaced that traditional contrast media. Physicians use noninvasive imaging methods for diagnosis and minimally invasive image-guided procedures during treatment (Thomas, A.M.K., Banerjee, A. K. & Busch, U., 2005; Busch, U., Banerjee, A.K., Thomas, A.M.K., 2005 April). In future, medical imaging will play an important role in making a shift from palliative medicine (Zerhouni, E.A., 2006).

5. Conclusion

Today, medical imaging is becoming more accurate, improving both in sensitivity and in specificity; creating 3D images and has the capacity to provide virtual presentation. It has significantly transformed the physicians' understanding of diseases in the ways of: measurement, management, diagnosis, treatment and prevention. As medical imaging improves, we can understand more about the pathobiology and can intervene much earlier. In future, in respect to growing innovations and technology, medical science will become a science of predicting diseases and imaging will play an important role in shifting healthcare science from the palliative role of today. The pace of innovations in medicine is accelerating, inspiring hope for better care and results. Now, by improvements we see in medical imaging, we can even see biochemical changes making the initial onset of disease therefore doctors will ultimately help patients to live longer, healthier lives. Medical imaging is widening human vision into the very nature of disease, providing accurate strong diagnosis of illness whilst enabling to intervene via a new and more powerful generation of methods. Introduction of the medical imaging, enabling stakeholders interested in promoting or considering adoption, to recognize the potential benefits might follow using these systems in medical care, and to direct the policy to enhance the quality of medical care sector. This article reviews medical imaging from the stem of X-rays to the new generations of molecular imaging, including CT scan, US, mammogram, MRI, digital angiography and PET scans.

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